HUMAN EMOTION RECOGNITION USING FUSED PHYSIOLOGICAL SIGNALS

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APPLICATIONS

PHYSIOLOGICAL SIGNALS

Table 1. Physiological signal types from BP4D+*.

Signal	Type	Measurement
Blood pressure	Diastolic Systolic Mean (dia/sys) Raw BP	[-25, 300 mmHG]
Respiration	Rate Volts	[0, 200 breaths/min]
Heart rate	Pulse rate	[30, 300 beats/min]
EDA	EDA	Micro Siemens

*Zhang et al., “Multimodal Spontaneous Emotion Corpus for Human Behavior Analysis,” CVPR 2016.

PHYSIOLOGICAL SIGNALS

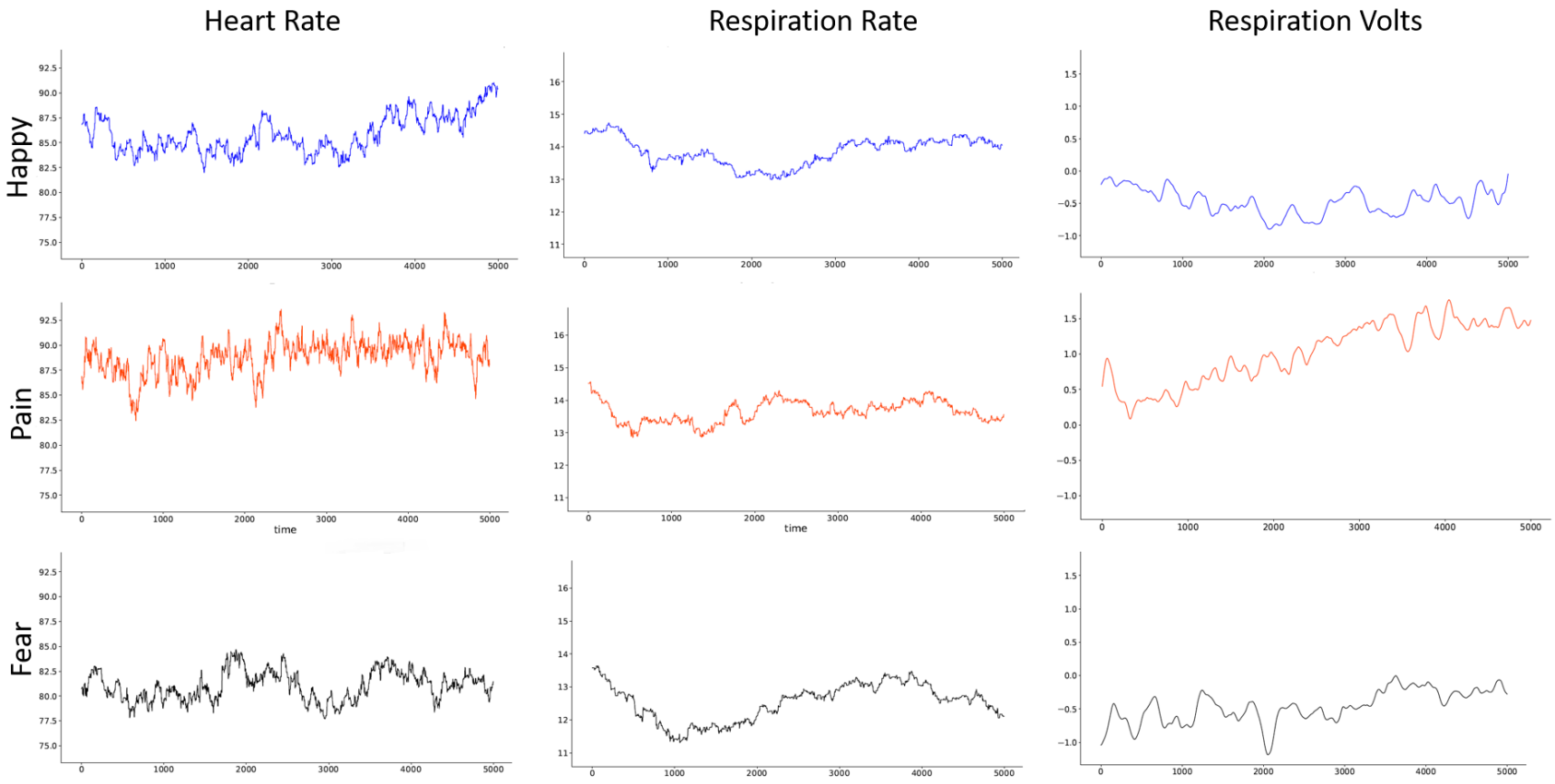

Figure 1. Comparison of signals for emotions of happy, pain, and fear.

FUSION OF PHYSIOLOGICAL SIGNALS

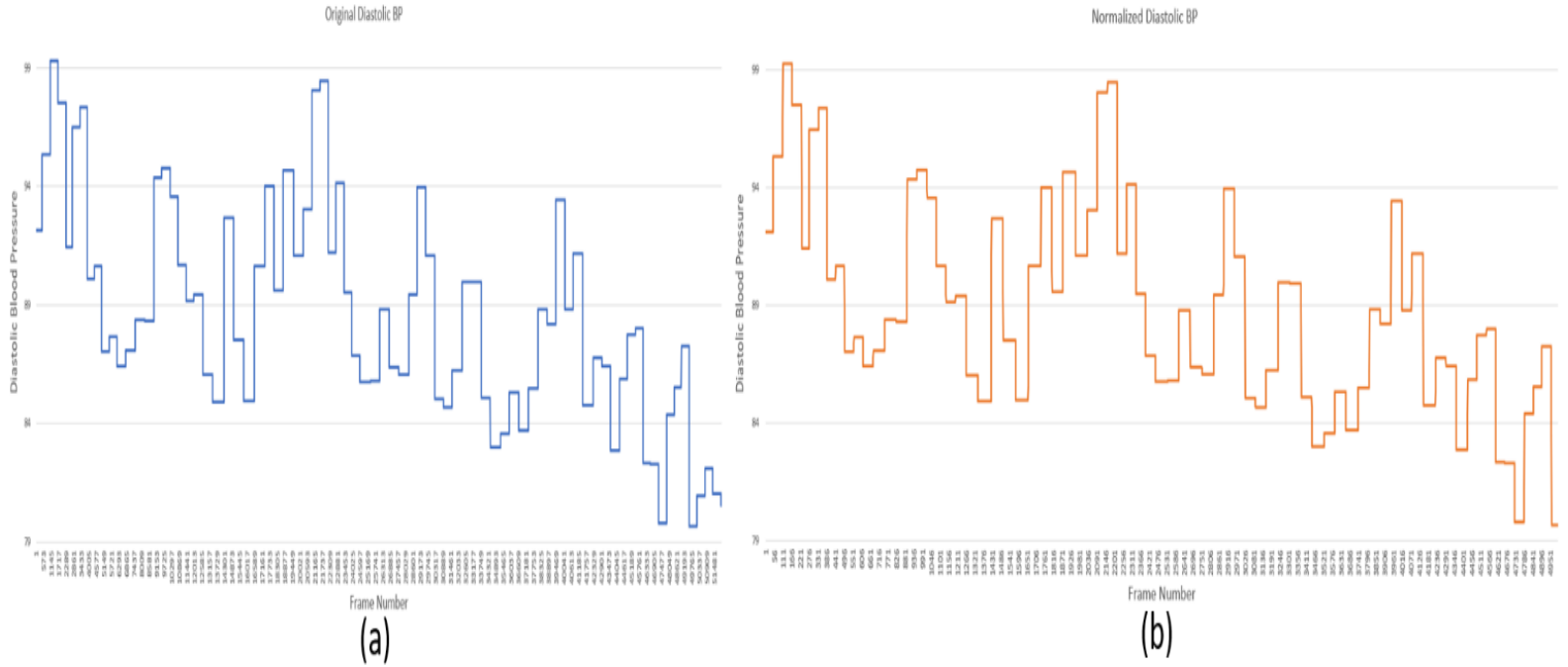

Figure 2. Diastolic blood pressure of female subject.
(a) Original signal; (b) normalized signal.

FUSION OF PHYSIOLOGICAL SIGNALS

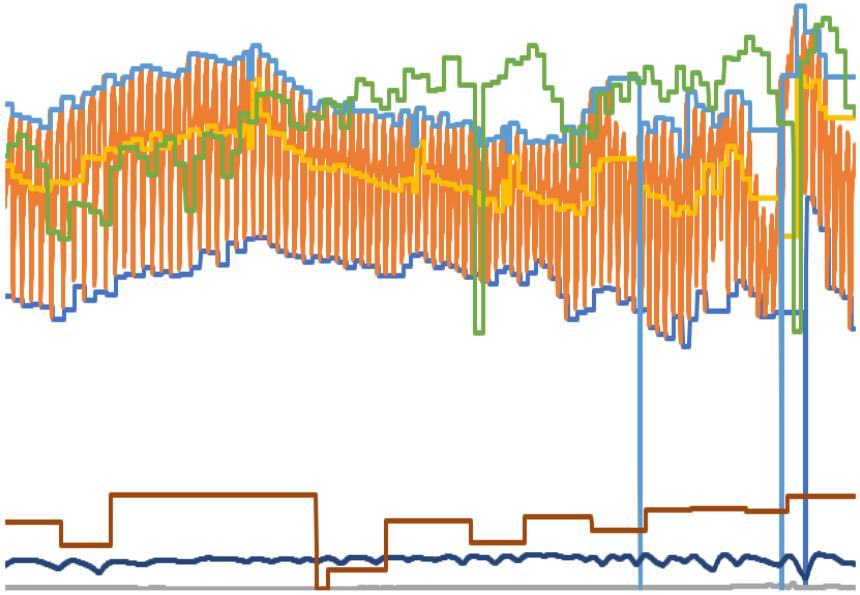

Figure 3. Physiological pain signals.

$$s^2 = \frac{\sum(x_i - \bar{x})^2}{n-1} \qquad (1)$$

$$fused_{signal} = \sum_{i=1}^{N} (ns_i{}^2 \times FS_i) \qquad (2)$$

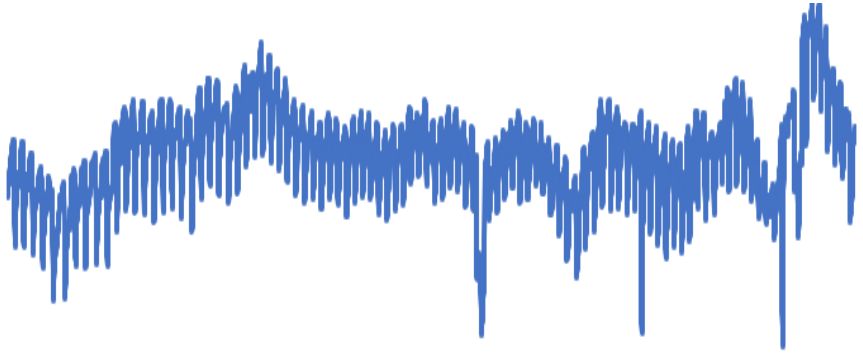

Figure 4. Fused pain signal.

EMOTION RECOGNITION WITH FUSED PHYSIOLOGICAL SIGNALS

Table 2. Recognition rates of 10 emotions.

Classifier	Accuracy
Support Vector Machine	**88.69%**
Naïve Bayes	86.87%
Random Forest	86.17%

Table 3. Recognition rates of pain vs. no pain.

Classifier	Accuracy
Support Vector Machine	**92.64%**
Random Forest	90.27%
Naïve Bayes	89.77%

Table 4. Prediction of 10 emotions.

Classifier	Accuracy
Random Forest	97.8%

EMOTION RECOGNITION WITH FUSED PHYSIOLOGICAL SIGNALS

Table 5. Recognition of 10 emotions with a deep feed-forward network.

Emotion	Fused Accuracy	Raw Accuracy (Exp 1)	Raw Accuracy (Exp 2)
Anger	**98.44%**	81.67%	84.05%
Happy	93.18%	71.96%	79.93%
Fear	92.70%	67.61%	79.84%
Embarrassment	92.08%	62.29%	84.19%
Startle	92.03%	74.85%	84.92%
Pain	91.37%	53.78%	84.23%
Sad	90.78%	49.09%	86.55%
Surprise	90.21%	63.42%	78.21%
Skeptical	90.00%	52.59%	79.93%
Disgust	85.14%	62.06%	75.72%
Average	**91.59%**	63.93%	81.16%

EMOTION RECOGNITION WITH FUSED PHYSIOLOGICAL SIGNALS

Table 6. Deep networks vs classical approaches for pain vs no pain.

Classifier	Accuracy
Deep Net Fused	**98.48%**
Deep Net Exp 1	97.14%
Deep Net Ext 2	95.36%
Support Vector Machine	92.64%
Random Forest	90.27%
Naïve Bayes	89.77%

BEYOND PHYSIOLOGICAL DATA

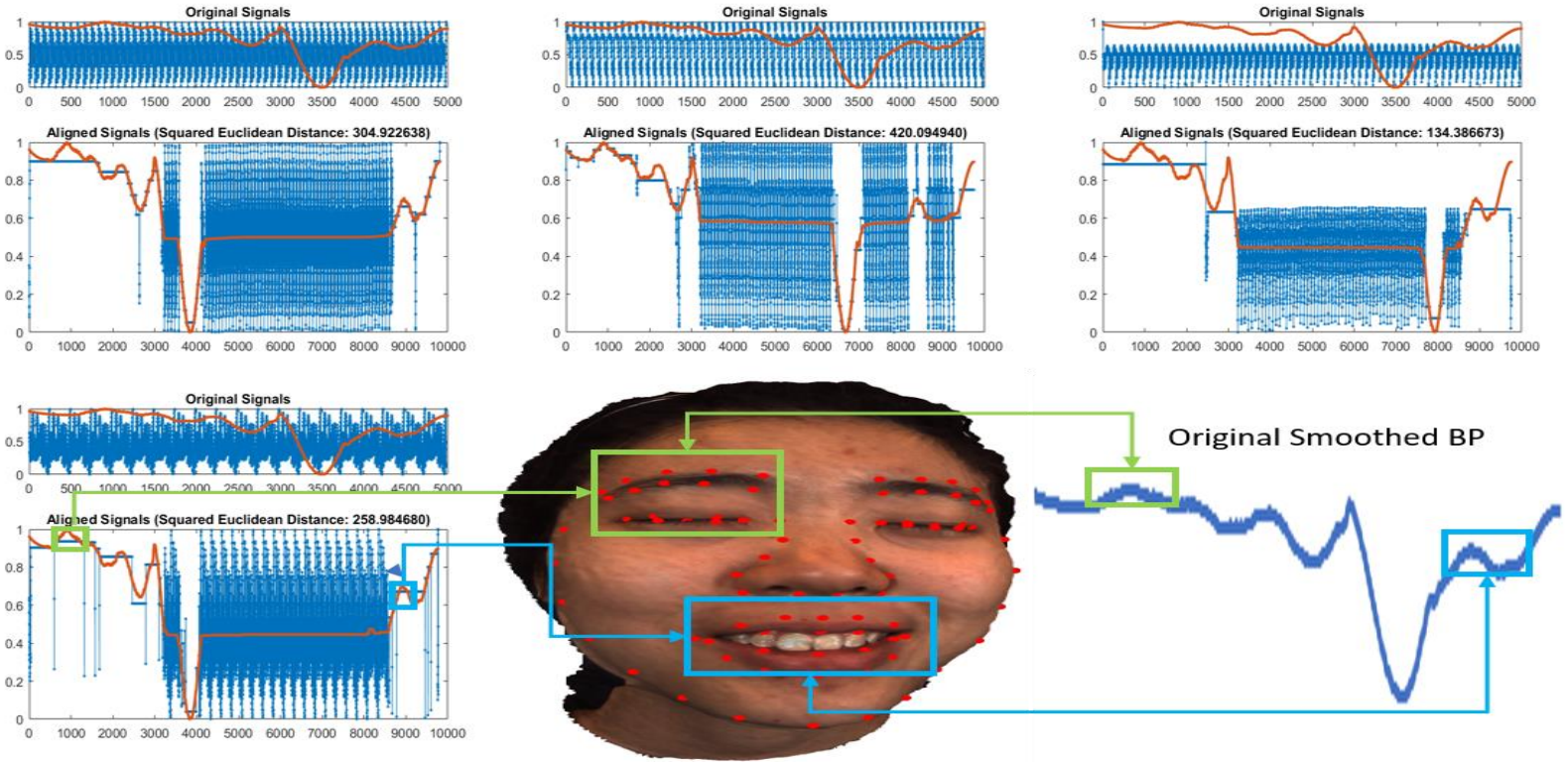

Figure 5. Inter-correlations between multiple modalities.

ACKNOWLEDGEMENTS

- Diego Fabiano
- Dr. Dmitry Goldgof
- Dr. Larry Hall
- Dr. Yicheng Tu
- Dr. Marvin Andujar

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